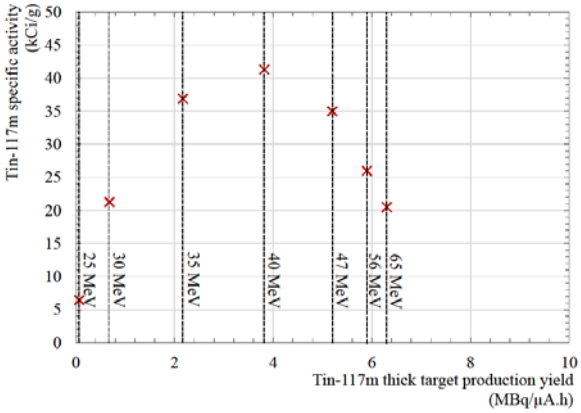

Conclusions: New experimental data have been obtained at the ARRONAX cyclotron that permits to expand the knowledge of the tin-117m TTY up to 65 MeV. The results of the TALYS 1.6 code, which reproduce correctly the tin-117m production cross section, have been used to determine the tin-117m SA taking into account the stables and long live tin isotopes produced during the irradiation. The highest tin-117m SA could be obtained using 40 MeV alpha beams which gives a TTY of 3.9 MBq/(µA.h). It is possible to get higher production yields but with a lower SA of the final product.

Keywords: tin-117m, ARRONAX cyclotron, specific activity

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Tb-155 production with gadolinium target: proton, deuteron or alpha beam?

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Purpose: Terbium is an element of growing interest for medical applications, considered as the "Swiss-knife of nuclear medicine" [1]. Indeed, four terbium radioisotopes can be used in nuclear medicine. Tb-149 is considered for alpha targeted therapy, Tb-161 for beta- targeted therapy, Tb-152 for Positron Emission Tomography (PET) and Tb-155 for Single Photon Emission Computed Tomography (SPECT). However, terbium-155 can also be used as a radionuclide that emits Auger electrons for therapy. The interest on this radioisotope is increased by the conversion electrons emitted and the possibility to follow the treatment by SPECT imaging in a theranostic approach. The Tb-155 production has been investigated using the deuteron beam delivered by the ARRONAX cyclotron [2] and natural gadolinium target, motivated by the lack of data for this reaction at the beginning of our experiments.
Materials/methods: Tb-155 production study has been considered at the ARRONAX cyclotron (France) taking advantage of the deuteron beam ranging from 15 to 35 MeV. Production cross section measurements of Tb-155 as well as radioactive contaminants have been made using the stacked-foils technique. The stacks were made of thin natural gadolinium as targets, aluminum foils as degraders and thin natural titanium as monitor foils. After irradiation, the activity of each radionuclides produced in the foils has been determined by γ spectrometry [3]. From the cross section values obtained during these experiments, the Tb-155 Thick Target production Yield (TTY) has been calculated and compared with the other Tb-155 production routes using data available in the literature. When no experimental data were available, the TALYS code [4] version 1.6 helped to estimate the TTY.
Results: In 2014, cross section values have been published for the Gd-nat(d,x)Tb-155 reaction [5]. Our set of data is in good agreement therewith. Tb-155 production cross section values for the Gd-nat(p,x) and Gd-nat(α,x) are also available in the literature. The Tb-155 TTY have been compared for each routes. Close values are obtained for the proton and the deuteron route. The Gd-nat(α,x) reaction gives the lowest TTY, whatever the incident beam energy. However, the use of a natural gadolinium target leads to the production of several contaminants and especially of Tb-156g which has the same half-life as Tb-155. Results based on calculations for two reactions using Gd-154 and Gd-155 enriched targets with, respectively, deuterons and protons as projectiles, are also discussed [3,6]. The Tb-159(p,5n)Dy-155(ε)Tb-155 reaction, with results published in 2014 [7], is also discussed as a promising production route using high energy protons.
Conclusions: New experimental data have been obtained at the ARRONAX cyclotron for the Gd-nat(d,x) reaction with a special emphasis on the Tb-155 production. The results have been compared with different production routes, using natural and enriched gadolinium target. Based on the calculations published in 2012 [6], the Gd-155(p,n) reaction seems to be the most promising for the production of Tb-155 with gadolinium as target element. However, the Tb-159(p,5n)Dy155(ε)Tb155 seems an interesting alternative.

Keywords: terbium-155, production routes, Thick Target production Yield

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RapidArc commissioning and dosimetric verification using EPID portal dosimetry system

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Purpose: In this study, we report the rapid arc commissioning and dosimetric verification measurements performed with the electronic portal imaging device (EPID) having portal dosimetry software.
Material and Methods: The dosimetric tests were performed on RapidArc capable Varian Unique linac, which is equipped with millennium 120 Dynamic Multi Leaf Collimators (DMLCs) and having 6 MV X-ray beam. The Varian RapidArc QA files, Eclipse treatment planning system (TPS) and EPID portal dosimetry system were used in this study. The RapidArc QA files incorporate following tests. 1) DMLC dosimetry. 2) Picket Fence (PF) test vs. gantry angle. 3) PF test during

Rapid Arc. 4) PF test during RapidArc with intentional errors. 5) Accurate control of dose rate and gantry speed during RapidArc delivery. 6) Accurate control of leaf speed during RapidArc delivery. These RapidArc QA plans were loaded on Machine and analysed using EPID portal dosimetry system.
Results and Discussion: Taking DMLC dosimetry, we measured meter reading at gantry angles 0°, 180°, 90° and 270° for a 4x10 cm DMLC field with a 0.5 cm slit, and the effect of gravity on leaf position and linac head showed maximum percentage deviation of -0.96% (± 2%). PF test at stationary gantry angles 0°, 180°, 90° and 270°, we evaluated the maximum DMLC positional shift of 0.5mm (± 1 mm). PF test during RapidArc (arc 179º-187º) has inspected the effect of gantry rotation on the MLC position, the result showed a maximum positional shift of -0.2 mm (± 1 mm). PF test during RapidArc with intentional errors have demonstrated that the test (3) can detect sub-millimetre errors during RapidArc. Accurate control of dose rate and gantry speed during RapidArc delivery has been examined by using 7 combinations of dose-rate, gantry range and gantry speed to give equal dose to seven 1.8 cm strips in a RapidArc field. When normalised to open field at same position (to exclude the beam profile influence), the dose of seven strips showed good result, with maximum mean deviation of 1.90% (< 2%). Accurate control of leaf speed during RapidArc delivery has been analysed by using 4 combinations of leaf speed (1.6, 2.4, 0.8 and 0.4 cm/s) and dose-rate to give equal dose to four strips in a RapidArc field. When normalised to corresponding open field, the dose of four strips showed good result, with a maximum mean deviation of 1.74% (< 2%). All the test results showed good agreement with manufacture and published literature stated tolerance values (written in bracket in front of each result).The RapidArc commissioning data has also obtained an approval from Atomic Energy Regulatory Board (AERB), Mumbai, India.
Conclusion: The dosimetric verification of DMLC movement, variable dose rates and gantry speed provides confidence over precision and accuracy during RapidArc delivery. These test are aimed only for commissioning and dosimetric verification of RapidArc enabled linac, and not for patient specific QA.

Keywords: Dosimetry, EPID, DMLC.

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Dosimetric Measurement for Isocentre Blocked Boost Fields in 3D-CRT Treatment Plans

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Purpose: Boost fields (A small field with isocentre blocked and less beam weightage) are routinely used in three dimensional conformal radiotherapy (3D-CRT) treatment plans of oesophagus, head and neck etc for enhancing PTV coverage. Challenges for using boost fields are associated with accuracy of treatment planning system (TPS) to calculate dose distribution, normalisation and monitor units (MUs) as isocentre is blocked so dosimetric verification of boost field is essential. The purpose of this study was to measure two things; first contribution of 'Boost fields' doses to the target isocentre, second doses to the region of interest of boost field and finally compare the dosimetrically measured data with TPS calculated data.
Materials and Methods: Eclipse TPS (Version 8.6, Varian) was used for all boost fields 3D-CRT treatment plans in this study. The solid water phantom with dimension (25cmx25mx5cm), (25cmx25mx2cm) and (25cmx25mx5cm) respectively was used. The 0.65cc ionisation chamber was used for dosimetry in this study with SAD (source axis distance) setup. In boost fields study, five treatment plans of oesophagus case each having two plans with 6MV and 15MV and each plan having two boost fields (one is LPO boost field and other is RPO boost field) were performed. The contribution of boost field doses to the target isocentre for both 6MV and 15MV plans were measured with the help of ionisation chamber and also calculated in treatment planning system. The doses to the region of interest of boost field at 5cm depth in phantom were measured with help of thermoluminescence detector (TLD-100) and also calculated in treatment planning system for both 6MV and 15MV plans. Finally the measured and calculated data was compared.
Results: Mean percentage variation between TPS calculated and ionisation chamber measured boost field doses to the target isocentre was 1.53% (SD 4.12) for 6MV and 4.13% (SD 6.81) for 15MV. Maximum Percentage variation for this was 6% and 12% for 6MV and 15MV respectively. Mean percentage variation between TPS calculated and TLDs measured boost field doses of region of interest of boost field was -1.22% (SD 2.03) for 6MV and -0.4% (SD 2.84) for 15MV. Maximum percentage variation for this was 4% and 5% for 6MV and 15MV respectively. TLDs were in good agreement with TPS. Results shows that contribution of boost field doses to the target isocentre for both 6MV and 15MV were less than 1cGy.
Conclusion: Dosimetric verification of MUs delivered by boost fields is essential to verify the accuracy of TPS algorithms.

Keywords: Boost Field, 3D-CRT, Isocentre

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The relationship between absorbed dose and DNA Damage in Lymphocytes after radionuclide therapy

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Purpose: In radionuclide therapy today mostly β^--labelled radiopharmaceuticals are used which irradiate the body internally with time-dependent dose-rate and can cause DNA double strand breaks (DSBs).
The formation of a DNA DSB in nuclear chromatin results in the rapid phosphorylation of the histone variant gamma-H2AX. DSBs also recruit the damage sensor 53BP1 to the chromatin surrounding the DSBs, which leads to 53BP1 and gamma-H2AX co-localization. By immunofluorescence staining with gamma-H2AX and 53BP1 antibodies those biomarkers can be addressed by microscopically visible foci.
The number of foci per cell represent a quantitative biomarker for DNA double strand breaks and hence for radiation exposure and radiation effects. Presently, there are only few studies, which are studying the on-set and decay of DSBs after radionuclide therapy.
The aim of our study was, therefore, to generate an in-vitro calibration curve for quantifying the dose-response of the number of radiation induced foci (RIF) after internal irradiation of blood with β^--emitters, and to describe comprehensively the dose-dependent time course of the DSB on-set and repair in lymphocytes of radiation treatment-naive patients after radiopeptide therapy with ^{177}Lu and radioiodine therapy with ^{131}I.
Material and Methods: For the in-vitro calibration with ^{131}I and ^{177}Lu blood samples were drawn from volunteers. Different activity concentrations were added, the samples were incubated for 1h to achieve absorbed doses up to 100mGy, and the number of RIF/cell was determined.
The patient studies addressed the relationship between the absorbed dose to the blood and the number and temporal behavior of radiation-induced DNA double strand breaks (RIF/cell) in multiple peripheral blood samples under radiopeptide therapy (16 patients) and under radioiodine therapy (20 patients).
Results: The in-vitro study shows that the number of RIF/cell is linearly dependent of the absorbed dose, similar to what has been observed after external irradiation.
In patients, the average number of RIF/cell showed a linear dose-response relationship within the first hours after administration of the radiopharmaceutical. Later time points were characterized by a diminishing number of radiation-